



OPEN SOURCE MIRROR TECHNOLOGY

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Lower weight | Lower cost | High reflectance

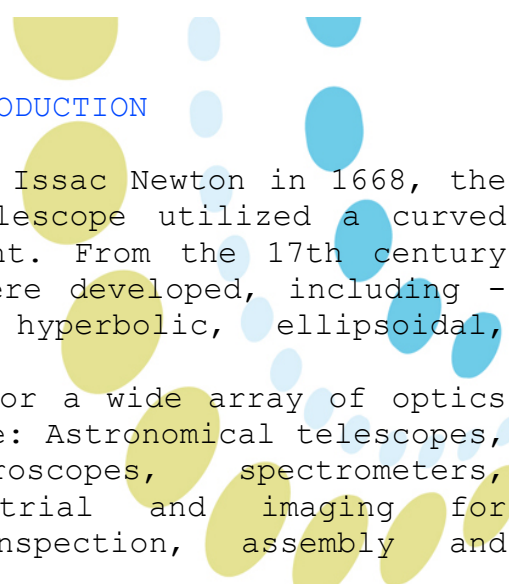
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MIRROR TECHNOLOGY INTRODUCTION

Since its first documented use by Sir Issac Newton in 1668, the reflecting telescope or newtonian telescope utilized a curved mirror known to gather or focus light. From the 17th century onwards, mirrors of various shapes were developed, including - concave and convex, parabolic, hyperbolic, ellipsoidal, spherical and perforated (Cassegrain).

The reflector has been used further for a wide array of optics applications. Such applications include: Astronomical telescopes, solar thermal collection, microscopes, spectrometers, interferometers, holographic, industrial and imaging for collection, sensing, detection, inspection, assembly and prototyping.

Most importantly, developments in optics and particularly reflecting technology gave researchers the tools to develop, test and refine scientific theories. This has enabled rapid technological advancement and most importantly allows us to [uncover laws of nature](#).

Currently the cost of heavy glass/metal mirrors and the cost of supporting those heavy-weight mirrors inhibits participation of the wider community in scientific and research processes. We would like to [change](#) that.

Renewable Thin Film Mirror (RTFM), Concave-Convex Membrane Mirror (CCMM) and RTFM Molding Apparatus (Pro-Ducer) constitute a new approach in the development of reflector technology - replacing glass-based reflecting mirrors with thin-film based mirrors within an open knowledge development framework.

Such mirrors are used for collecting of electromagnetic waves, whether it is in the visible spectrum of light, infra-red, radio or a wave of any frequency.

This device functions by reflecting energy from a larger reflective surface area and focuses and concentrates the light energy into a smaller area where it can be collected for a wide range of applications and processes.

Overall weight of the RTFM and CCMM is significantly less than traditional glass curved mirrors - expanding aperture capability while lowering cost of telescope mounting.

RENEWABLE THIN FILM MIRROR¹ (RTFM)

RTFM demonstrates high reflectivity, uniform shape and figure using a thin film and renewable thermoplastic resin (GEL 1.0). The renewable thermoplastic resin provides excellent molding

¹ >95% of the mirror material by weight is originated from flora and fauna, which with careful management is renewable.

intricacy, adhesion and stability whilst minimising resource intensity and ecological footprint.



*Illustration 1: RTFM - Top surface.
114mm (4.5 inches) aperture; 150 grams
total weight.*

collector.

RTFM technology offers researchers an innovation of process - **swift design** - using **lightweight replenish-able** (renewable) & recyclable materials.

RTFM is composed of reflective thin-film (such as BoPET) adhered or laminated to bio-polymer (GEL 1.0) which takes the form of an electromagnetic wave reflector or

RTFM is highly reflective - averaging at 90%, depending on the quality of materials used. Thin films using special aluminium and silver with oxide enhanced optical coatings, can produce reflectance above 99% for certain wavelengths ².

PRO-DUCER MOLDING APPARATUS

Pro-Ducer Molding Apparatus is at the core of this mirror construction technology allowing production of curved thin film mirrors from renewable and inexpensive materials. The Pro-Ducer is efficient, easy to assemble and install, compact and lightweight. Latter properties allow minimisation of valuable laboratory space, while reducing transportation costs. This Pro-Ducer Molding Apparatus enables construction of mirrors which are concave/convex of any focal length greater than $\sim F/1.2$.

PRO-DUCER MOLDING APPARATUS CONFIGURATION

- Our current mold allows the production of 114.3 mm (4.5 inch) to 8 inch (203.2 mm) concave hyperbolic mirrors. However, mirrors can be produced of various apertures (mirror's outer diameter), sagittas and mold shapes. Mold for making mirrors of larger apertures is currently being tested.
- As sagitta is increased with respect to the outer diameter of the produced mirror, the focal ratio and distance to the primary point of focus of incident paraxial electromagnetic rays is decreased.
- The following shapes can be used in production: concave,

² Minghong Yang *et al* 2006 *J. Opt. A: Pure Appl. Opt.* **8** 327-332

convex, conical, spherical, parabolic, hyperbolic, or other ellipsoidal or spheroidal shape.

- Pro-Ducer molding apparatus is a flexible membrane mirror and molded optics production device. RTFM devices can be made using renewable molding materials. Additionally other kinds of membrane reflector devices utilising less material can be created such as the Convex/Concave Membrane Mirror (CCMM).

- In Glass mirror making, during annealing, rapid cooling of glass substrate can generate an uneven temperature distribution in the body of the material which can result in surface or figure irregularities. With RTFM production, differential thermal contraction can also be a factor causing cracking, voids, sweating or other irregularities. Using cork for mirror backing (as a top insulating layer of molded structure) insulates GEL and allows for gradual and even cooling rates. Annealing cooling rate depends on the thickness of cork, and can range from several tens of degrees celsius per hour for thinner material to a fraction of a degree Celsius per hour for thicker molded GEL composed RTFMs with cork backing, eliminating necessity of purchasing temperature controlled kilns or other electronic molding equipment. Further, the use of silicone-rubber molding templates introduces a flexible, compressive and temperature-resistant pressure-molding element serving the function of forming the depth of the part.

RTFM PRODUCTION PROCESS OVERVIEW

To produce a concave mirror, force is applied to shape thin-film reflective material onto the mold. Reflective thin film (such as Mylar or Innovia) is centred and tensioned into the shape using simple and inexpensive pressurisation techniques - gravity and mass of metal.

Renewable molding agent is transferred to the reflective thin film material and pressurised, usually solidifying within 24-48 hours depending on composition/temperature. Mirror is then de-pressurised, excessive materials are cut off and baffling is applied. Result - high reflectance lightweight mirror.

For high quality optic properties, it is desirable to avoid impurities/dust/particles on the mold or thin film before the application process. This allows to minimise imprints on the final mirror surface.

RTFM PRODUCTION PROCESS ADVANTAGES

- Usually production of glass reflectors is very labour-intensive and often a small mistake in the figuring or polishing process can lead to many additional hours of corrective actions.

- RTFMs can be produced in a fraction of the time, using a fraction of the resources and reliably reproduced to very nearly exactly the same optical figure each and every time of production owing to the use of a unique molding process (Pro-Ducer).
- Depending on the molding materials used, very uniform, permanent and highly reflective surfaces can be achieved. Fast focal ratios can be obtained and the form, shape and figure of the RTFM can be maintained using renewable thermoplastic resin for the molding process. The natural thermoplastic compound used in the process demonstrates excellent molding intricacy and adhesion while minimising resource intensity and ecological footprint, with potential to stimulate growth of sustainable industries.

RTFM MOLDING MATERIALS – RENEWABLE THERMOPLASTIC RESIN

GlucoEucaLac (GEL 1.0) is synthesised from the composition of Glucose (saccarides), Eucalyptus(solvent) and Shellac(polyester type of resin), which is secreted by certain type of insects.



*Illustration 2: Thermosetting
GlucoEucaLac 1.0 – Plant and insect
derived Thermoplastic Resin*

GEL 1.0 bio-polymeric compound is annealed and molded into a bio-composite structure, which demonstrates microbial resistance and biodegradability properties.

Depending on the composition and annealing temperature of GlucoEucaLac, dense and dimensionally stable structures are achieved.

RENEWABLE THERMOPLASTIC RESIN CONCLUSION

In addition to being used as a molding agent in the construction of thin-film mirrors, GEL 1.0 can be used for a wide range of industrial applications: Thermoplastic injection molding, 3D printing, pressure molding, adhering, bonding, filling and repairing.

ADDITIONAL PERMUTATION – CONCAVE-CONVEX MEMBRANE MIRROR (CCMM)

Concave-Convex Membrane Mirror(CCMM) is a reflector device

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composed of reflective thin film membrane which has been stretched or deformed into a parabolic or hyperbolic curved shape. The produced CCMM device can be in either a convex or concave state by applying air, vacuum or mechanical pressure against either side of the membrane to push or pull it into convex or concave state. The sagitta of the mirror can be specified by applying the right amount of force to the desired shape using the Pro-Ducer molding apparatus. It is observed the aluminium (AlO₂) coating on the BOPET / thin-film is conforming, warping or stretching into a convex or concave figure or shape.



Illustration 3: CCMM in its Convex and Concave States

CCMM is highly reflective averaging at 90%, depending on the quality of materials used.

CCMM PRODUCTION PROCESS OVERVIEW

Concave object of desired parameters is imbued onto the mold. Reflective thin film (such as Mylar or Innovia) is centred and tensioned into the shape using simple and efficient pressurisation device. Allow time for material to train into shape. Result - high reflectance lightweight mirror.

For high quality optic properties, it is desirable to avoid impurities/dust/particles on the mold or thin film before the application process. This allows to minimise imprints on the final mirror surface.

There are many potential applications of CCMM technology. One exciting application could be a propulsion system powered by oscillation of the membrane, whilst focusing the electromagnetic waves on hydrogen or other combustible or compressible gas or material.

CCMM ADVANTAGES

- No chemicals used in the process. It is swift and produces a mirror with dual concave/convex capabilities which can be changed or oscillated with little force using air, vacuum or mechanical pressure.
- Mirror cost is reduced virtually to negligible as only thin film and a supporting structure are engaged.

CONCLUSION

RTFM and CCMM technology offer reduced weight, lower materials cost and reduced production intensity while providing efficient thin-film reflector technology.

GEL 1.0 offers a renewable alternative, which is much needed by long-sighted societies.

These technologies are suitable for application in a wide range of areas. It is hoped that the world community receives this technology well, using it for peaceful purposes and the betterment of human kind.

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DISCLAIMER

We encourage the development of this technology for astronomy applications. We advise against the use of Cfree mirror devices for any solar related purposes. Utilisation of the mirrors for those purposes should be undertaken only by persons and/or organisations qualified in safe handling of concentrated solar power. Never look through your optics at the sun. Permanent blindness, property damage or injury could occur if proper safety precautions are not taken when using reflector devices.

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